Federal Land Assistance, Management and Enhancement (FLAME) Act Suppression Expenditures for Interior and Agriculture Agencies:

July 2015 Forecasts for Fiscal Year 2015

Supporting Documentation

Report Date: June 12, 2015

Executive Summary

In FY 2015, the U.S. Department of Agriculture Forest Service is forecast to spend:

Median forecast	$1.199 billion
90% confidence range of forecast	$869 million to $1.529 billion
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2014 FLAME)	$1.122 billion
Previous median forecast (March 2015 FLAME)	$1.259 billion
Previous median forecast (May 2015 FLAME)	$1.216 billion

These forecasts are reported in Tables 1-3 and Figure 1.

In FY 2015, the bureaus of the U.S. Department of the Interior are forecast to spend:

Median forecast	$259 million
90% confidence range of forecast	$182 million to $335 million
Forecast tercile of historical expenditures since 1985	Middle
Previous median forecast (September 2014 FLAME)	$356 million
Previous median forecast (March 2015 FLAME)	$382 million
Previous median forecast (May 2015 FLAME)	$378 million

The DOI forecasts are reported in Tables 4-5 and Figure 2.

Overview

With the passage of the FLAME Act in 2009, both the U.S. Department of Agriculture Forest Service (USDA) and the Department of the Interior (DOI) are required to produce forecasts of annual suppression expenditures three times during each fiscal year: March, May, and July, with a September outlook for the next fiscal year required when the next fiscal year budget is not approved by Congress and the President by that date. Scientists at the USDA Forest Service Southern Research Station provide these forecasts to both the Forest Service and the DOI.

Modeling

Modeling Framework for the July 2015 FLAME Act Forecast of FY 2015 Forest Service Expenditures

To meet the statutory requirements of the FLAME Act, the Forest Service developed statistical models based on peer reviewed research.[1,2] These models have been developed for several forecast horizons and are generally specified as a system of equations. Each of the three equations contained in the current modeling system represents a statistical relationship between historical expenditures and a set of predictor variables for Forest Service regional aggregates. These equations were estimated using ordinary least squares regression (OLS).

This report is the fourth forecast issued for FY 2015. The current approach forecasts expenditures by Forest Service regional aggregates for the West (Regions 1-6) and the East (Regions 8 and 9). The expenditures made by the National Interagency Fire Center, Washington Office, and research stations continue to be modeled as an aggregate, which we label in this report as "RFS." This RFS category is combined with Region 10, Alaska, because there relatively few expenditures on suppression in Region 10. This report differs from previous July FLAME Act forecasts in two ways: (1) cost pools were included in the forecast rather than added in at the end, (2) data covers FY 1995 to 2014 while last year's models used data from only FY 2005 to 2013, and (3) gross domestic product deflators consistent with the President's budget were used.[3]

The statistical models relate spending in the coming fiscal year to measures of drought from May of the current FY, a dummy variable for structural change starting in FY 2000, and time. The models had moderate R^2's, ranging from 0.43 to 0.81. Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within the acceptable (insignificant) or inconclusive range.

Forecasts were made using the equation estimates shown in Table 6 for the West, East, and RFS expenditures. Data used for modeling were annual fiscal year totals of expenditures for 1995 to 2014. Total Forest Service expenditures are also available for 1985-1994, and some comparisons are made to this longer time series. To erase the effects of general price inflation, all expenditures were deflated to the value of a dollar in 2014 using the gross domestic product deflator used in the President's budget—that is, models were estimated and expenditures were forecast in "real" dollar terms.

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[1] Prestemon, J.P., K.L. Abt, and K. Gebert. 2008. Suppression cost forecasts in advance of wildfire seasons. Forest Science 54(4):381-396.

[2] Abt, K.L., J.P. Prestemon, and K. Gebert. 2009. Wildfire suppression cost forecasts for the US Forest Service. Journal of Forestry 107(4):173-178.

[3] http://www.whitehouse.gov/sites/default/files/omb/budget/fy2015/assets/hist.pdf

After the forecast, we adjusted the forecast values to put them in current dollars. When generating a forecast distribution (see Figure 1), we randomly sampled from equation error distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo forecasts, which are repeated 50,000 times, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution is summarized as: a forecast density distribution; a table reporting a median forecast and the lower and upper bounds of likely observed expenditures;[4] and a table of not-to-exceed expenditures by probability levels. We also describe where the median forecast value for each region falls within the observed historical expenditures for other years, in real dollar terms.

Model fitness is reported in Table 7 and Figure 3. Table 7 shows how well the July 2015 FLAME Act forecast model performs by measuring the errors developed from out-of-sample forecasts (produced by dropping the observation of the forecast year, and doing this iteratively over the historical data, a technique sometimes termed "cross-validation") compared with observed expenditures for the Forest Service. The Root Mean Squared Error of the July 2015 FLAME Act model, calculated over FY 1995-2014, was $196 million.

The forecast had a positive bias, tending to over-forecast each year, on average, by about $10 million (0.97 percent). We do not adjust the current forecast using this bias. The model had a Mean Absolute Percent Error of 22 percent, meaning that the typical forecast averaged 22 percent above or below expenditures actually incurred during the 1995-2014 time span. Finally, this model correctly predicted the year-over-year direction of change in suppression expenditures by the Forest Service 89 percent of the time. The median FY 2015 expenditures are forecast to be lower than the actual FY 2014 expenditures (Figure 3).

Modeling Framework for the July 2015 FLAME Act Forecast of FY 2015 Department of the Interior Expenditures

The forecast model for the DOI was based on departmental total expenditure data—i.e., aggregated across all agencies and geographic regions. The July 2015 FLAME Act model covered department wide expenditures for FY 1985-2014.[5] We modeled aggregate DOI expenditures using a model specification that includes the Palmer Drought Severity Drought Indices for May corresponding to Forest Service Regions 2, 3, and 8, and a variable to represent years after 2000. This model is an update of the May FLAME Act model that has the same independent variables with the Palmer Indices from March.

The DOI suppression expenditure forecast equation is reported in Table 8. The estimated equation explained 91 percent of the variation ($R^2 = 0.91$) in annual DOI suppression expenditures over the historical time period, 1985-2014. The Durbin-Watson statistic (1.72)

[4] It is possible for the lower bounds of the distribution to be less than or equal to zero when suppression expenditures are predicted to be low but the sampled error is larger. Our interest is primarily on the upper end of the distribution.

[5] Although geographical and agency disaggregated data are available for recent years (since the early 2000's), there are insufficient data for modeling by geographic region or agency within the Department.

indicated no evidence of residual autocorrelation in the model estimation errors. As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2015 is illustrated with the probability density graphic (Figure 2) developed with 50,000 Monte Carlo random forecasts.

Model fitness for the July FLAME Act forecast model for DOI is reported in Table 9. As in the case of the Forest Service forecast, the DOI July FLAME Act forecast model was evaluated by making cross-validated forecasts of DOI expenditures, then generating the model evaluation diagnostics presented in Table 9. This July forecast model had a Root Mean Squared Error of $46 million when calculated over 1985-2014 and a small positive bias. As with the Forest Service, we do not adjust the forecasts for any historical prediction bias.

The typical forecast was off by 15 percent for the 1985-2014 time span, according to the Mean Absolute Percent Error. The model correctly predicted the direction of change in suppression expenditure for the agency from one year to the next 79 percent of the time between 1986-2014.[6] Figure 4 shows how this previously issued FLAME Act forecast models compare with observed expenditures for the Department. The median FY 2015 expenditures are forecast to be lower than the actual FY 2014 expenditures.

Results

The USDA Forest Service is forecast to have fire suppression expenditures in the upper tercile since 1985 and the middle tercile since 1995. The DOI is forecast to have fire suppression expenditures in the middle tercile since 1985.[7] The USDA Forest Service median forecast is slightly above the September median which was based on a single equation model of total expenditures; but below the medians from the March and May FLAME forecast medians because the July model uses the most recent drought information. The DOI median forecast in this report is much lower than in the past forecasts also because of the use of the most recent drought information.

USDA Forest Service

The median forecasts for each of the regions, and for the USDA Forest Service total, are reported in Table 1, along with the 80, 90 and 95% confidence intervals. Table 2 contains probabilities of falling below specific dollar amounts by regional aggregate and in total. Table 3 reveals that, when compared to expenditures since 1995, the West, East, and total Forest Service are forecast to be in the middle tercile in 2015 while RFS is forecast to be in the upper tercile. Using a longer time series since 1985 for the USDA Forest Service total indicates suppression expenditures are forecast to be in the upper tercile.

[6] Direction of change is calculated based on the change from the previous year's data, therefore, can only be calculated from 1986-2014 in the case of the Department of the Interior. The USDA Forest Service system contains a lagged dependent variable for RFS therefore reducing the years that we can forecast (and evaluate the forecast) to 1996-2014.

[7] The USDA Forest Service models use data only since 1995 as regional level data are not adequate prior to that date. Total USDA Forest Service expenditures are available, and considered reliable, so we do the comparison.

The drought conditions in May (Regions 3, 6, and 8) increase the expenditures, as expected[8]; however, southern Region 5 has a small and opposite sign possibly because the coastal effects are captured in the Region 6 drought coefficient.[9] Suppression expenditures have been higher in the years since 2000 across the west and are increasing over time for RFS.

Department of the Interior

The median forecast expenditure from the Monte Carlo simulation for the Department is in the middle tercile in real dollar terms compared to the observed expenditures since 1985. The outcome is the result of drought conditions in the central and southeastern United States and higher average expenditures since 2000.

[8] Westerling, A.J., A. Gershunov, D.R. Cayan, T.P. Barnett. 2003. Long lead statistical forecasts of area burned in western U.S. wildfires by ecosystem province. Int. J. Wildl. Fire 11(3– 4):257–266; Littell, J.S., D. McKenzie, D.L. Peterson, and A.L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916–2003 19(4): 1003-1021.

[9] We examined the fit of the total USDA Forest Service system without the southern Region 5 drought measure and the errors were larger (RMSE larger by $17 million).

Table 1. July 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, by region and in total in current year (FY 2015) dollars.

	West	East	RFS	Total Forest Service
Median Estimate	824	51	325	1,199
80% Confidence Lower Limit	575	4	146	944
80% Confidence Upper Limit	1,073	99	504	1,457
90% Confidence Lower Limit	504	(2)	95	869
90% Confidence Upper Limit	1,144	105	554	1,529
95% Confidence Lower Limit	443	(5)	51	806
95% Confidence Upper Limit	1,205	108	598	1,594

Table 2. July 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service by region and in total, probability of falling below specified amount in FY 2015 dollars.

Probability (%) of falling below indicated dollar amount	West	East	RFS	Total Forest Service
1	372	(7)	(0)	728
5	504	(2)	95	869
10	575	4	146	944
20	661	16	207	1,033
30	722	28	251	1,095
40	775	40	289	1,148
50	824	51	325	1,199
60	873	63	360	1,251
70	926	75	398	1,306
80	988	87	442	1,370
90	1,073	99	504	1,457
95	1,144	105	554	1,529
99	1,276	110	650	1,671

Table 3. Tercile forecasts of FY 2015 suppression expenditures from the July 2015 FLAME Act model.

Region	Forecast Tercile
West (since 1995)	Middle
East (since 1995)	Middle
RFS (since 1995)	Upper
Total FS (since 1995)	Middle
Total FS (since 1985)	Upper
Total DOI (since 1985)	Middle

Table 4. July 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the Department of the Interior in FY 2015 dollars.

	(Millions of 2015$)
	Total DOI
Median Estimate	259
80% Confidence Lower Limit	199
80% Confidence Upper Limit	318
90% Confidence Lower Limit	182
90% Confidence Upper Limit	335
95% Confidence Lower Limit	168
95% Confidence Upper Limit	350

Table 5. July 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the Department of the Interior probability of falling below specified amount in FY 2015 dollars.

Probability (%) of falling below indicated dollar amount	Realized amount (Millions of 2015$)
1	151
5	182
10	199
20	220
30	234
40	247
50	259
60	271
70	283
80	298
90	318
95	335
99	367

Table 6. Ordinary least squares regression equation estimates used in the July 2015 forecast of FY 2015 suppression expenditures of the USDA Forest Service.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
West Expenditures	Constant	492,784,555	96,470,620	5.11	<0.0001	0.81	2.18
	Region 3 May Palmer S-Index	(93,395,768)	21,922,665	(4.26)	0.0001		
	Region 5 South May Palmer S-Index	27,150,177	15,405,956	1.76	0.0841		
	Region 6 May Palmer S-Index	(105,004,303)	29,196,929	(3.60)	0.0007		
	Years 2000 on	219,400,015	113,425,580	1.93	0.0587		
East Expenditures	Constant	48,641,922	6,021,524	8.08	0.0000	0.43	2.36
	Region 8 May Palmer X-Index	(19,990,538)	5,421,475	(3.69)	0.0006		
RFS Expenditures	Constant	(23,022,927,543)	9,971,529,054	(2.31)	0.0251	0.44	1.21
	Region 3 May Palmer H-Index	(21,498,519)	11,207,293	(1.92)	0.0608		
	Year	11,572,936	4,977,731	2.32	0.0242		

Note: The dependent variable is the annual total real dollar suppression expenditures for each regional aggregate.

Table 7. Cross-validation of the ordinary least squares regression model used in the July 2015 FLAME Act forecast of FY 2015 suppression expenditures of the USDA Forest Service calculated over data from 1995-2014 in FY 2015 dollars.

	Millions of 2015 dollars	Percent
Root mean square error	196	-
Bias	10	-
Percent bias	-	0.97
Mean absolute percent error	-	22
Percent correct direction of change	-	89

Table 8. Equation estimates used in the July 2015 FLAME Act forecast of FY 2015 suppression expenditures of the Department of the Interior.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
DOI Expenditures	Constant	210,618,916	11,285,744	18.66	<0.0001	0.91	1.72
	Region 2 May Palmer S-Index	(18,922,594)	3,996,867	(4.73)	0.0001		
	Region 3 May Palmer S-Index	(13,407,026)	3,069,590	(4.37)	0.0002		
	Region 8 May Palmer S-Index	(30,585,058)	5,937,465	(5.15)	<0.0001		
	Years 2000 on	108,346,602	19,252,868	5.63	<0.0001		

Note: The dependent variable is the Department's annual real dollar suppression expenditures.

Table 9. Cross-validation of the equation used in the July 2015 FLAME Act forecast of FY 2015 suppression expenditures of the Department of the Interior calculated over data from 1985-2014 in FY 2015 dollars.

	Millions of 2015 dollars	Percent
Root mean square error	46	-
Bias	0.134	-
Percent bias	-	0.05
Mean absolute percent error	-	15
Percent correct direction of change, 1986-2014	-	79

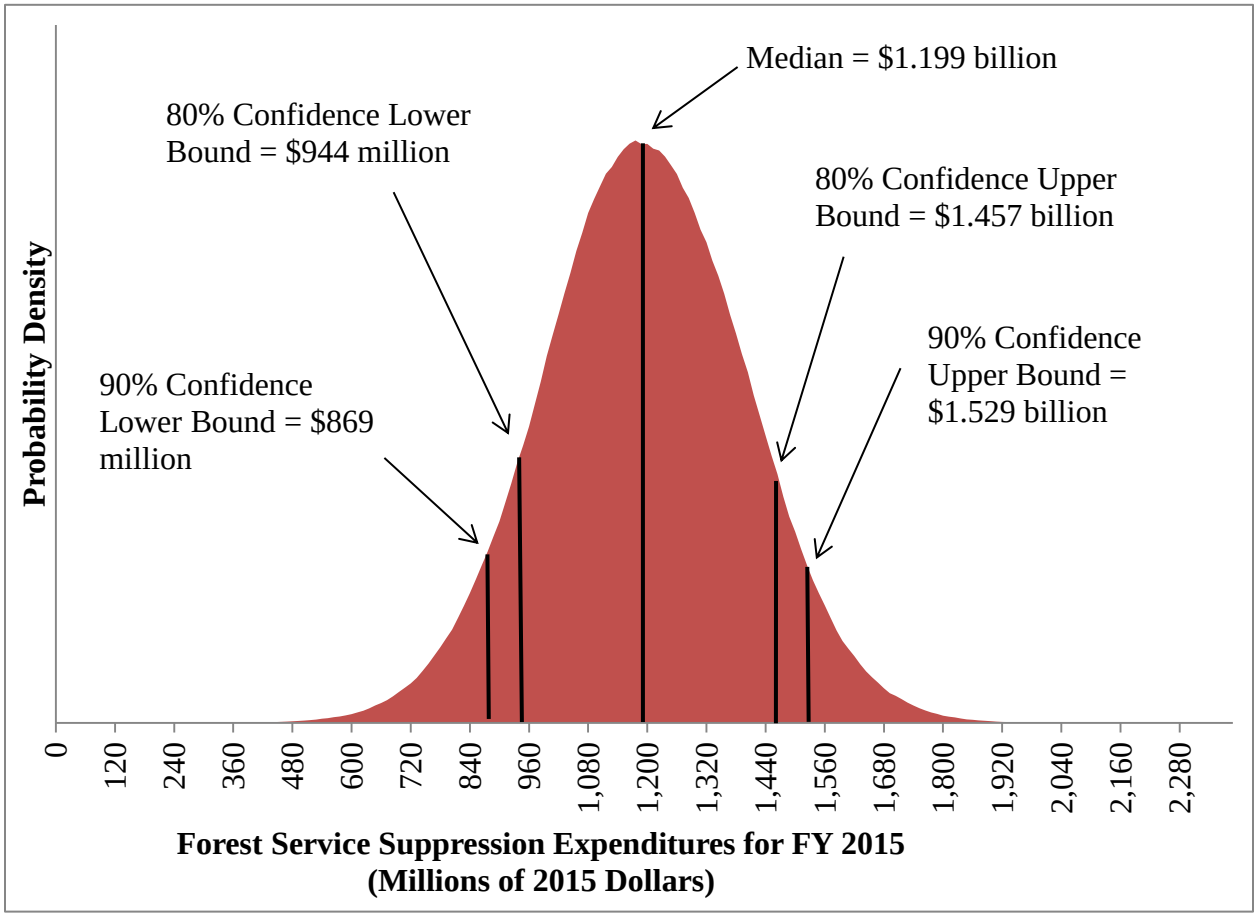

Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2015, July 2015 FLAME Act forecast model.

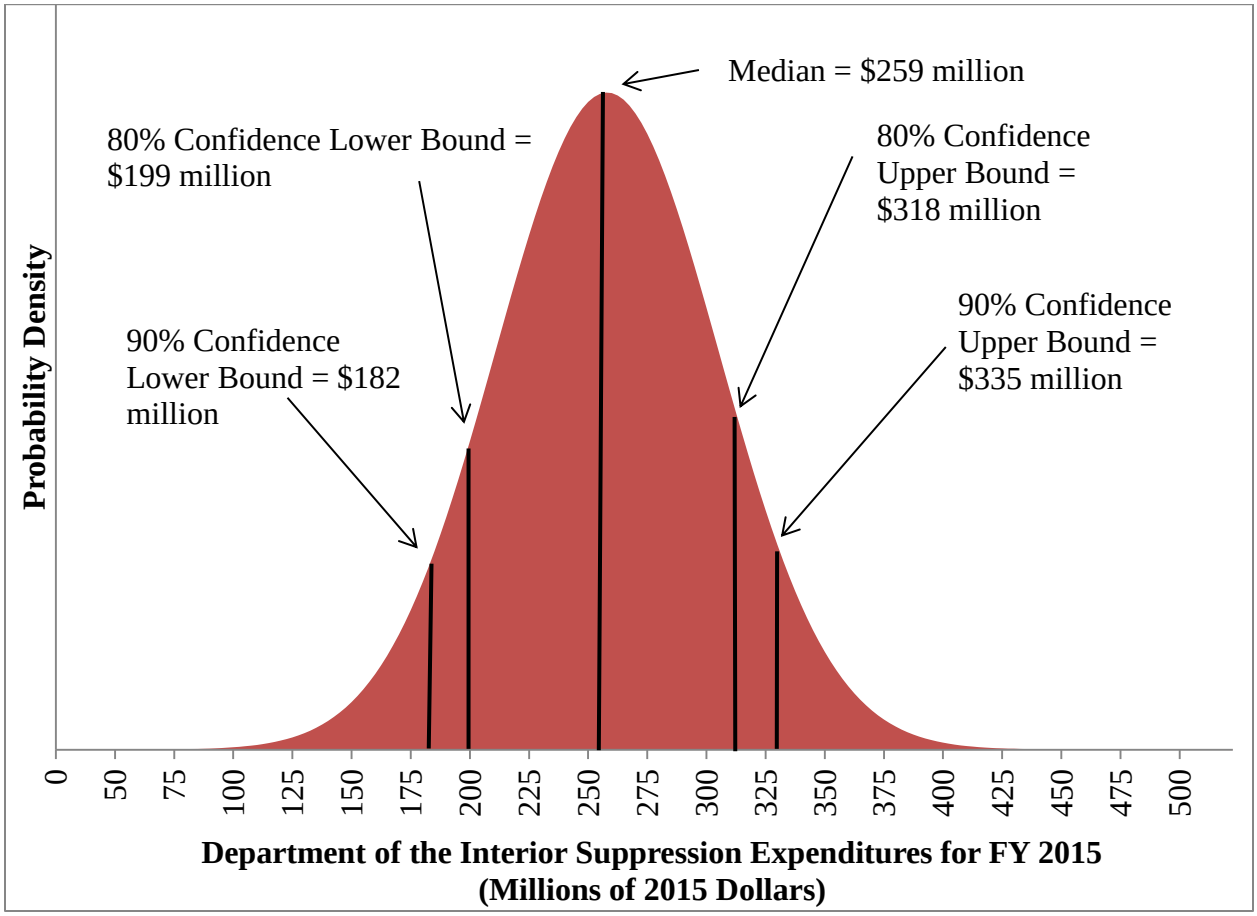

Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2015, July 2015 FLAME Act forecast model.

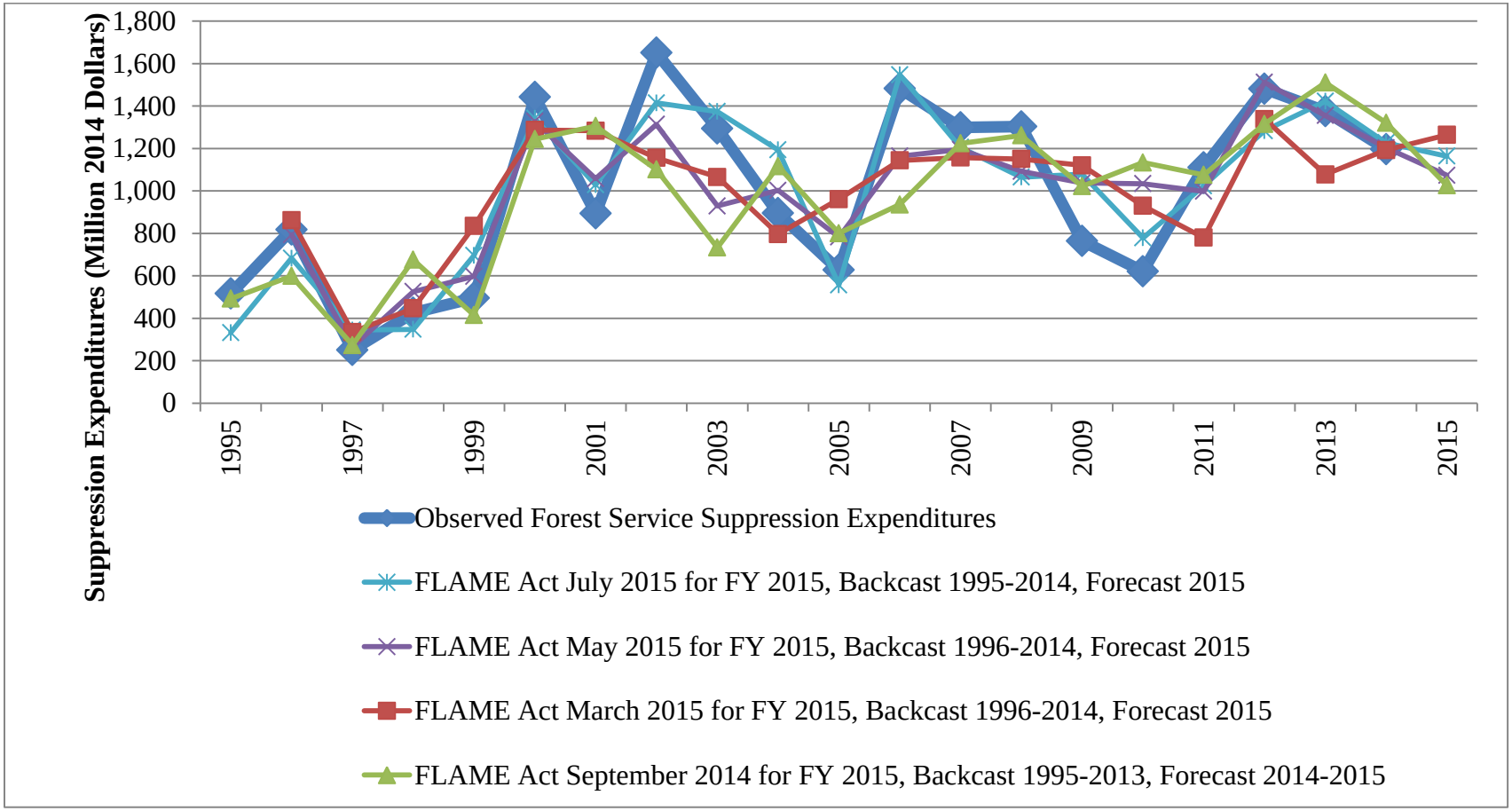

Figure 3. Observed historical USDA Forest Service suppression expenditures and the forecasts of these expenditures (1995-2015), using the July 2015 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's expenditures generated with a cross-validation procedure. (Note: values are in constant 2014 dollars and include the wildland fire suppression cost pool expenditures.)

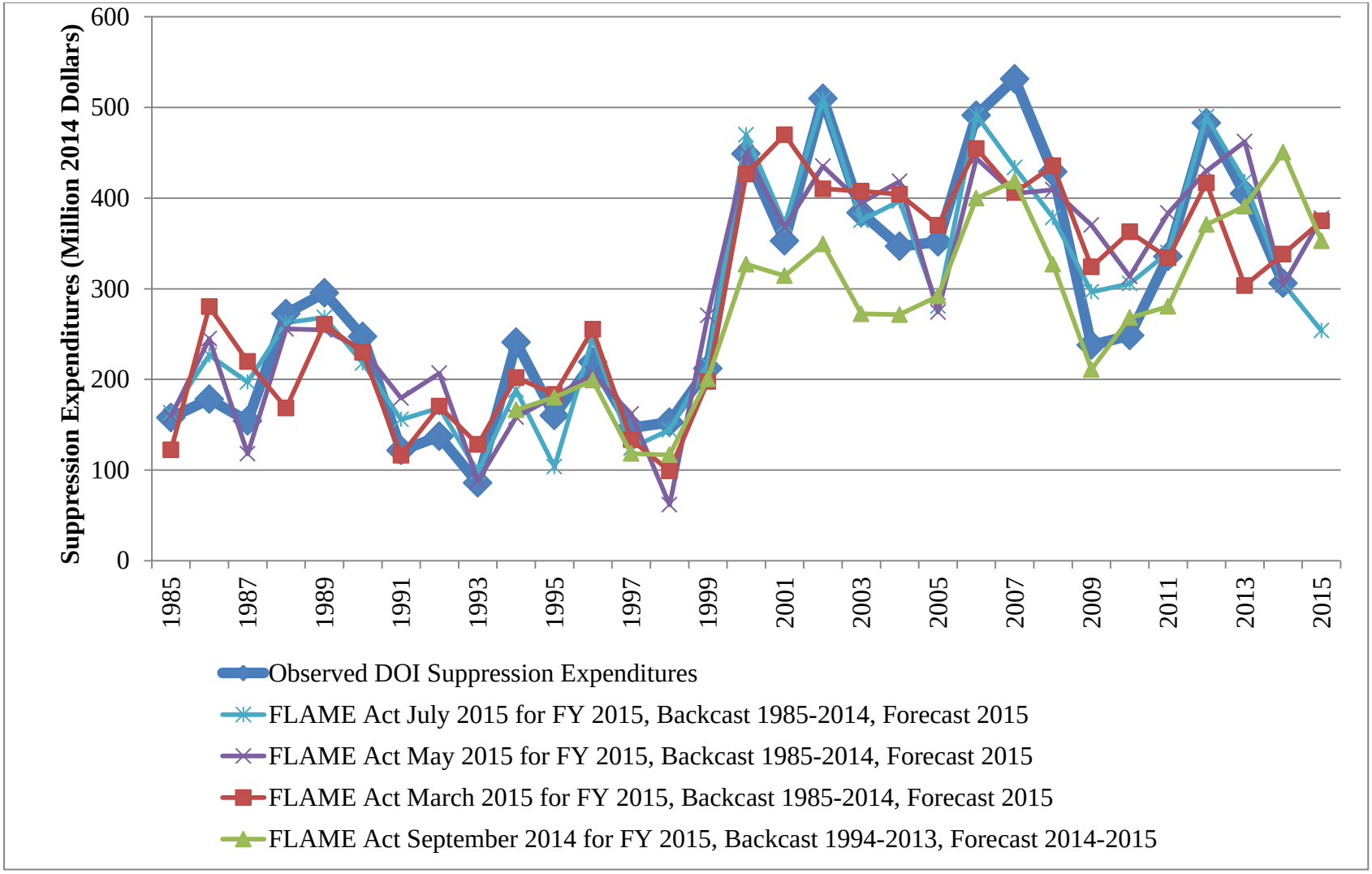

Figure 4. Observed historical Department of the Interior suppression expenditures and the forecasts of these expenditures (1985-2014), using the July 2015 FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2014 dollars)